Universal Gravitation Practice   Name:______________________________

1. The mass of the Earth is 5.98×10^{24} kg, and the surface is **6371 km** from the centre of the planet.

   6.371×10^6 m

   a. Use the law of Universal Gravitation to determine the magnitude of the force of gravity pulling a 1.0 kg object on the surface of the Earth downwards.

$$F_g = G\frac{m_1 m_2}{r^2} = 6.674 \times 10^{-11}\,\frac{N \cdot m^2}{kg^2} \times \frac{5.98 \times 10^{24}\,kg \times 1.0\,kg}{(6.371 \times 10^6\,m)^2}$$

$$= 9.83\,N$$

   b. What is the magnitude of the force of gravity pulling the earth toward the 1.0 kg object?

   9.83 N as well

2. Two students, one with a mass of 56 kg and one with a mass of 72 kg stand so that their centres of mass are 0.35 metres apart. What is the force of gravity pulling the students together?

$$F_g = G\frac{m_1 m_2}{r^2} = 6.674 \times 10^{-11}\,\frac{N \times m^2}{kg^2} \times \frac{56\,kg \times 72\,kg}{(0.35\,m)^2}$$

$$= 2.2 \times 10^{-6}\,N$$

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3. Two asteroids each weighing 5.00×10^6 kg are placed a certain distance apart. What is the magnitude of the force of gravity acting on each of them if

   a. The distance between their centres is 500.0 m?

$$F_g = 6.674 \times 10^{-11} \frac{Nm^2}{Kg^2} \times \frac{(5.00 \times 10^6 kg)(5.00 \times 10^6 kg)}{(500.0 m)^2}$$

$$= 6.67 \times 10^{-3} N = 0.00667 N$$

   b. The distance between the centres is 250.0 m?

$$F_g = 6.674 \times 10^{-11} \frac{Nm^2}{Kg^2} \times \frac{(5.00 \times 10^6 kg)(5.00 \times 10^6 kg)}{(250 m)^2}$$

$$= 2.67 \times 10^{-2} N = 0.0267 N$$

   c. The distance between their centres is 5.00 m?

$$F_g = 6.674 \times 10^{-11} \frac{Nm^2}{Kg^2} \times \frac{(5.00 \times 10^6 kg)(5.00 \times 10^6 kg)}{(5.00 m)^2}$$

$$= 66.7 N$$

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4. An 85 kg astronaut is 65 m from the centre of their spaceship which has mass of 98 000 000 kg.
   a. What is the force of gravity acting to pull the astronaut towards the spaceship?

$$F_g = 6.674 \frac{N m^2}{Kg^2} \times \frac{(85 kg)(98\,000\,000 kg)}{(65 m)^2} = 1.32 \times 10^{-4} N$$

   b. What is the acceleration of astronaut towards the spaceship?

$$F_{net} = ma \rightarrow \frac{F_{net}}{m} = a \rightarrow \frac{1.32 \times 10^{-4} N}{85 kg} = 1.55 \times 10^{-6} m/s^2$$

   c. If the acceleration was constant at the value from b, how long would it take the astronaut to travel 1.0 metre toward the spaceship?

$a = 1.548 \times 10^{-6} m/s^2$

$d = 1.0 m$

$V_0 = 0$

$$d = v_0 t + \frac{1}{2} a t^2$$

$$t = \sqrt{\frac{2d}{a}} = 1137 sec \approx 19 min$$

   d. Why would the acceleration NOT be constant if the astronaut was pulled all the way to the spaceship?

F_g will increase as the object gets closer, so acceleration will increase as the object gets close to the station.

Universal Gravitation Practice Name:________________________

5. The mass of the Earth is 5.98×10^{24} kg, a 1500 kg satellite orbits the Earth in uniform circular motion a distance of 1.6×10^7 metres from the centre of the Earth.
   a. What is the force or gravity acting on the satellite?

$$F_g = 6.674\times10^{-11} \frac{Nm^2}{kg^2} \times \frac{(5.98\times10^{24}kg)(1500kg)}{(1.6\times10^7 m)^2} = 2338.5N$$

   b. What is the period of rotation for the satellite?

$$F_c = F_g \qquad F_c = \frac{4\pi^2 rm}{T^2} \rightarrow T = \sqrt{\frac{4\pi^2 rm}{F_c}}$$

$$= \sqrt{\frac{4\pi^2(1.6\times10^7 m)(1500kg)}{2,338.5}}$$

$$= 20\,128.7 sec \approx 5.59 hours$$

6. The mass of the Earth is 5.98×10^{24} kg, the mass of the moon is 7.35×10^{22} kg, and the centres of the moon and the Earth are 3.84×10^8 m apart.
   a. What is the force of gravity from Earth acting on the Moon?

$$F_g = 6.674\times10^{-11} \frac{Nm^2}{kg^2} \times \frac{(5.98\times10^{24}kg)(7.35\times10^{22}kg)}{(3.84\times10^8 m)^2}$$

$$= 1.99\times10^{20} N$$

   b. What is the period of rotation for the moon expressed in days if the moon orbits in uniform circular motion?

$$F_c = F_g \rightarrow T = \sqrt{\frac{4\pi^2 rm}{F_c}}$$

$$= \sqrt{\frac{4\pi^2(3.84\times10^8 m)(7.35\times10^{22}kg)}{1.99\times10^{20} N}}$$

$$= 2\,366\,644 sec \times \frac{1 min}{60 sec} \times \frac{1 hr}{60 min} \times \frac{1 day}{24 hr}$$

$$= 27.4 days$$

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7. The mass of the Earth is 5.98×10^{24} kg, the period of Earth's orbit around the Sun is 365.24 days, and the distance between the Earth and the Sun is 151 million kilometres. Determine the mass of the Sun if we assume the Earth moves around the Sun in uniform circular motion.

1.51 million km = 1.51×10^{11} metres   365.24 days = 31556736 sec

$$F_c = F_g \rightarrow \frac{4\pi^2 r\, m_{Earth}}{T^2} = G\frac{m_{sun}\, m_{Earth}}{r^2}$$

$$\frac{4\pi^2 r^3}{T^2 G} = m_{sun}$$

$$\frac{4\pi^2 (1.51 \times 10^{11}\,m)^3}{(31556736\,sec)^2 \times 6.674 \times 10^{-11}}$$

$$= 2.05 \times 10^{30}\ kg$$

8. [illegible] is orbiting Ear[illegible], with speed of 15 [illegible] radius of [illegible] orbit?